



## Sinus membrane elevation and implant placement

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**Abstract** (J Korean Assoc Oral Maxillofac Surg 2020;46:292-298)

Sinus Schneiderian membrane elevation surgery is widely performed for dental implant placement in the maxillary posterior region. With regard to sinus elevation surgery, various complications can occur and lead to implant failure. For successful implants in the maxillary posterior region, the clinician must be well acquainted with sinus anatomy and pathology, a variety of bone graft materials, the principles of sinus elevation surgery, and prevention and management of complications.

**Key words:** Sinus membrane elevation, Complication, Success

[paper submitted 2020. 7. 27 / accepted 2020. 7. 27]

### I. Introduction

Dental implants in the maxillary posterior region are known to exhibit poor clinical outcomes due to lack of residual bone height and poor bone quality. Various surgical techniques have been developed to compensate for bone quality and quantity of the maxillary posterior region. Regarding insufficient residual bone height, sinus Schneiderian membrane elevation should be performed to prevent maxillary sinus invasion of dental implants. Although bone grafting surgery is commonly accompanied by this procedure, sinus membrane elevation is performed without bone grafting. These surgical techniques have been introduced using the following terms: sinus graft, sinus bone graft, sinus lift graft, sinus augmentation, maxillary sinus augmentation, maxillary

sinus floor bone grafting, sinus lift (elevation), sinus membrane elevation, sinus floor elevation, sinus filling (packing), and sinus repair<sup>1</sup>. Concerning sinus elevation surgery, many studies have been classified candidates into relative and absolute contraindications, but the decision of surgical technique is mainly dependent on the preference and experience of the clinician<sup>2</sup>.(Table 1)

### II. Types of Sinus Membrane Elevation Surgery

Sinus membrane elevation surgery is classified into crestal (internal sinus lift, socket lift) and lateral (lateral sinus lift) approaches. Generally, the type of approach is selected based on residual bone height. The crestal approach is safe in cases of residual bone height greater than 5 mm, and bone height of 3-4 mm can be obtained. The lateral approach is recommended when residual bone height is 5 mm or less<sup>3</sup>.

#### 1. Crestal approach

Since the 1990s, sinus membrane elevation has been performed using an osteotome technique such as osteotomy sinus floor elevation (OSFE), bone added OSFE (BAOSFE), future site development (FSD), and trabecular compaction<sup>4,5</sup>.

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**Table 1.** Classification of contraindications

Absolute contraindications
① Sinus neoplasms
② Chronic polypous sinusitis
③ Mucocele
④ Severe allergic rhinitis
⑤ Paranasal sinus fungal infection
Relative contraindications
① Chronic maxillary sinusitis receiving otolaryngologic treatment
② Very small size of the maxillary sinus
③ Mucous retention cyst
④ Maxillary sinus surgery history: high incidence of failure and complications because the sinus is commonly filled with poorly vascularized scar tissue

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Recently, however, these techniques have not been widely used due to their high risk of sinus membrane perforation and complications. In addition, many devices have been developed that can safely contribute to the crestal approach. To prevent the risk of complications such as sinus perforation, head trauma, and vertigo, devices such as balloons, hydraulic pressure, special reamers, and piezoelectric drills are used<sup>5-9</sup>. With regard to the crestal approach, many implants are simultaneously placed with the approach, and bone grafting is performed based on the amount of elevation required and the preference of the clinician.

## 2. Lateral approach

The lateral approach is mainly performed when residual bone height is <5 mm or pathologic conditions are observed in the sinus. After forming a lateral window with various instruments, the sinus membrane can be elevated. Even though special surgical techniques with various instruments and drills have been developed to minimize risk of sinus membrane perforation, surgeon skill and experience is critical to prevent complications<sup>9,10</sup>.

### 1) Sinus membrane elevation without bone grafting

Many studies have reported on the lateral approach without bone grafting. To maintain the space without lowering the membrane after sinus lift, the area is packed with a resorbable membrane, titanium mesh, collagen sponge, platelet-rich plasma (PRP) gel, resorbable polymeric thermos-reversible gel (Ploxamer), reoxidized cellulose, or venous blood<sup>11-14</sup>. Several studies have reported that sinus bone formed an average height of 4.7-9.1 mm. To achieve stable and successful outcomes, the condition of the maxillary sinus should be healthy, and the sinus membrane must not be perforated dur-

ing surgery. This technique is recommended in cases of residual bone height >5 mm, with new bone formation expected to be approximately 3 mm<sup>15,16</sup>.

### 2) Bone graft materials for sinus grafting

Autogenous bone graft has the advantage of a shortened healing period. Without autogenous bone, the healing period can be as long as 8 months<sup>17,18</sup>. Use of autogenous endochondral bone (e.g., tibia and iliac bone) has become rare due to complications with donor site<sup>19</sup>. Recently, many clinicians have been harvesting block or particulated autogenous bone at an intraoral site (e.g., mandible, maxilla, and zygoma) and including other bone substitutes to increase the amount of harvested bone<sup>20-22</sup>.

Allogeneic, xenogeneic, and alloplastic bone substitute materials are used alone or in combination. To promote new bone formation, bone substitutes can be incorporated with platelet-rich fibrin (PRF), PRP, and recombinant human bone morphogenetic protein-2 (rhBMP-2). Xenogeneic bones are mainly manufactured from bovine, equine, and porcine species. Alloplastic bone substitutes such as hydroxyapatite (HA), calcium sulfate, beta-tricalcium phosphate ( $\beta$ -TCP), and bioactive glass have generally been used for sinus bone grafting. In recent years, most alloplastic bone products have been composed independent of any other products or in a specific ratio with HA and  $\beta$ -TCP<sup>23-28</sup>.

Generally, any bone substitutes can be expected to have a successful outcome with sinus bone grafting if there is no sinus-related pathology, a healthy Schneiderian membrane, proper residual bone height, and no perforation during surgery<sup>29-31</sup>. Some studies have suggested that application of 0.25-1.00 mm of granular bone graft could enhance bone formation because of the intimate contact surface with the recipient bone wall<sup>32</sup>. However, Chackartchi et al.<sup>33</sup> reported that particle sizes of 1.00-2.00 mm and 0.25-1.00 mm exhibited similar results, with smaller-size particles showing greater resorption. Therefore, the authors recommended a mixture of small- and large-size particulated bone graft for large defects.

### 3) Simultaneous versus delayed implant placement

For primary stability of implants, simultaneous implant placement should be performed on residual bone height  $\geq 3$  mm, and delayed implant placement should be considered in areas of 1-2 mm of residual bone height. When considering these indications, simultaneous and delayed methods have shown similar successful outcomes<sup>34</sup>.

#### 4) Lateral window formation

It is evident that the smaller is the size of the lateral window; the better is the bone formation. A smaller window has a high risk of sinus membrane perforation due to the narrow operating field. Active new bone formation can be achieved with clear membrane elevation to create an enclosed space with surrounding bone, similar to an extraction socket.

The trapdoor technique has been widely used to form the lateral window by fracturing the window inward and moving it upward with membrane elevation. However, the risk of membrane perforation increases in cases with sinus septum. Some clinicians prefer to reposition the window after membrane elevation with bone graft material<sup>35</sup>. Other clinicians have argued that removal of the window with a diamond bur or reamer is easier and safer for lifting the membrane. After removing the window, a barrier membrane should be used to cover the window defect to prevent soft tissue ingrowth<sup>36</sup>.

### III. An Alternative Technique for Sinus Membrane Elevation

Maxillary tuberosity implants, short implants, and tilted implants have been introduced to avoid the maxillary sinus during implant therapy<sup>37</sup>. Chiapasco and Zaniboni<sup>38</sup>, however, noted that sinus membrane elevation with bone grafting is better suited for the final prosthesis as it allows the implant to be placed in an ideal position even though it is more invasive and involves higher complication risk.

### IV. Healing After Sinus Bone Grafting

The healing period varies depending on several variables, including residual bone height, sinus cavity width, graft material, age of the patient, smoking history, and complications such as sinus membrane perforation and infection. In general, a healing period of 6-8 months is required between placement of the bone graft material and maturation of new bone<sup>39</sup>. It is clear that the higher is the residual bone from the sinus floor, the shorter is the healing period, the lower is the complication risk, and the higher is the success rate of bone grafting

**Table 2.** Intraoperative complications

1. Implant fixture sinus displacement
2. Posterior alveolar superior artery bleeding
3. Sinus membrane perforation
4. Implant protrusion into the maxillary sinus

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and implant placement<sup>40</sup>. Bone healing after sinus grafting is related to sinus width—the narrower is the width, the better is the prognosis<sup>41</sup>.

### V. Complications

With regard to sinus membrane elevation surgery, some complications are inevitable even though prevention is the best method. Once complications occur, the clinician should acquaint themselves with the cause, explain the issue to the patient, and treat the complications accordingly. Cases of serious complications should be promptly referred to a related specialist<sup>42</sup>. During surgery, the most common complication is sinus membrane perforation, which could increase the risk of postoperative infection and failure of the graft and/or implant. Therefore, it is necessary to be aware of the various methods for closing perforations. After surgery, an infection is the most common complication, early diagnosis and treatment (antibiotics and incisional drainage) of which are very important for prevention of severe problems<sup>43,44</sup>. (Tables 2, 3)

To minimize complications such as bleeding and sinus membrane perforation, the normal anatomical structures and pathological findings should be identified and diagnosed before surgery. Cooperation with an otorhinolaryngologist should be considered in cases of asymptomatic maxillary sinus lesion, nasomeatal patency, chronic maxillary sinusitis, mucous retention cyst, and nasal septum deviation<sup>45</sup>. To prevent arterial bleeding, the clinician should evaluate the vertical resorption of alveolar bone and the position of the posterior superior alveolar artery<sup>46</sup>. Sinus lateral wall thickness is very different for each individual. If the wall thickness is too thin or thick, there is a high possibility of perforation of the sinus membrane during formation of the bony window<sup>47</sup>. Asymptomatic mucous retention cyst and antral pseudocyst are not a contraindication. However, mucocoeles with extensive and destructive aspects are contraindication for sinus membrane elevation. Sinus elevation is often difficult in cases with

**Table 3.** Postoperative complications

1. Implant fixture sinus displacement
2. Hematoma
3. Wound dehiscence
4. Postoperative infection: maxillary sinusitis, graft material infection
5. Benign paroxysmal positional vertigo
6. Continuous neuropathic pain
7. Oroantral fistula
8. Infraorbital nerve damage

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mucous retention cyst or pseudocyst, where aspiration with a 21-gauge needle could be effective for sinus elevation, bone grafting, and implant placement<sup>48</sup>. Sinus septum has been reported in 16%-58% of patients and could increase risk of membrane perforation<sup>49</sup>. Normal sinus membrane thickness is 0.3-0.8 mm, and cilia cells remove various secretions and foreign substances formed in the maxillary sinus. If there is a lesion causing maxillary sinusitis or a history of sinus-related surgery, risk of postoperative complications such as maxillary sinusitis greatly increases because the cilia cells cannot function normally<sup>50</sup>. The most important factor to identify before surgery is maxillary ostium patency (osteomeatal patency), lack of which could cause postoperative maxillary sinusitis due to an issue with the maxillary sinus drainage system. In addition, risk of postoperative complications also increases in cases of nasal septum deviation and nasal mucosa inflammation or injury<sup>51</sup>.

## VI. Clinical Outcomes

### 1. Implant protrusion into the maxillary sinus

In an *in vivo* study of implant protrusion into the maxillary sinus, protrusion  $\leq 2$  mm was well covered with maxillary sinus mucosa, but protrusion  $> 3$  mm was not completely healed by the mucosa and may have resulted in a secondary infection<sup>52</sup>. Ragucci et al.<sup>53</sup> reported in a clinical study that protrusion  $< 4$  mm resulted in a significantly lower incidence of maxillary sinusitis. Therefore, implant protrusion  $< 3$  mm with sinus membrane perforation and loss of bone graft material should not be removed because of its ability to achieve osseointegration.

### 2. Failure of sinus bone graft

Anavi et al.<sup>54</sup> reported the poor prognosis of implants in cases of previous sinus-related treatment and re-operation after complications from sinus bone graft surgery. Regarding treatment of chronic oroantral fistula reconstruction or re-operation with sinus bone grafting, Kim and Kim<sup>55</sup> noted that sinus infection management should be considered with reconstruction of the sinus roof using a pedicled buccal fat pad and collagen membrane, oroantral fistula closure, and sinus bone graft using autogenous bone.

### 3. Residual bone height and sinus width

The crestal approach sinus lifting has fewer complications and higher success rates compared to lateral approach sinus lifting. This is attributed to the typical residual bone height greater than 5 mm when using the crestal approach<sup>56</sup>.

### 4. Sinus membrane elevation and implant placement

Simultaneous or delayed implant placement is determined by residual bone height. Therefore, direct comparison of prognosis is not appropriate between the two, and both have good prognoses if the timing of implant placement is determined based on all indications. The primary factor for implant success is primary stability<sup>57</sup>. Risk of implant failure greatly increases when implants are placed simultaneously with sinus bone graft and vertical ridge augmentation<sup>58</sup>.

### 5. Risk factors of implant failure in the maxillary posterior region

Sinus membrane elevation surgery is not directly related to implant failure. The main risk factors associated with implant failure are smoking, non-submerged implant, insufficient residual bone height, sinus membrane perforation, and postoperative maxillary sinusitis<sup>59,60</sup>.

## VII. Summary

1) Ideal bone graft materials have yet to be determined. However, a mixed bone graft (autogenous bone and other bone substitutes) has advantages in reducing the healing period and increasing bone density at the graft site over time compared with bone grafts using a certain material alone.

2) To prevent complications, the clinician should establish a careful preoperative examination and treatment plan based on the maxillary sinus structures. If lesions originating from the sinus are diagnosed before surgery, treatment should be performed with otolaryngology consultation.

3) Early detection and appropriate management are important to treat complications and prevent severe outcomes.

4) Several factors affect healing of maxillary sinus bone graft and prognosis of implants, the most important of which is residual bone height.



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## Author's Contributions

Y.K.K. participated in the literature review and wrote the primary manuscript. J.K.K. participated in the literature review and wrote the final manuscript.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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**How to cite this article:** Kim YK, Ku JK. Sinus membrane elevation and implant placement. *J Korean Assoc Oral Maxillofac Surg* 2020;46:292-298. <https://doi.org/10.5125/jkaoms.2020.46.4.292>